Fire history of Glacier National Park...

FINAL REPORT FOR COOPERATIVE AGREEMENT
#87232 WITH SYSTEMS FOR ENVIRONMENTAL
MANAGEMENT

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# Fire History of Glacier National Park:

## McDonald Creek Basin

Final Report

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Systems for Environmental Management

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## Introduction

In 1987 Glacier National Park (GNP), in cooperation with the USDA Forest Service Intermountain Experiment Station and Systems for Environmental Management, initiated a fire history study in the McDonald Creek basin on the park's west side. This study was part of a several year effort to document fire's historical role in GNP's forest ecosystems. Previous studies have described fire's role in the North Fork of the Flathead River drainage (Barrett 1983, Key 1983), which comprises GNP's western boundary, and the Middle Fork of the Flathead River drainage (Barrett 1986), the park's southern boundary. Three separate studies were considered necessary because different forest types exist within the study areas, thus, potentially different fire histories. These data contribute to natural fire planning for GNP's west-side forests because the data reveal past fire frequencies and burning patterns, as well as information on the post-1900 role of fire suppression.

## Study Area

The study area is a relatively wide and long glacial valley draining southwest from the Continental Divide to the GNP boundary near West Glacier, Montana (fig. 1). To supplement the park's geographic information system, limited sampling also was conducted in the adjacent Camas Creek drainage, northwest of the McDonald basin, and in the Apgar Mountains, a small range to the southwest. When combined, these 3 areas total about 98,000 acres (39,676 ha).

The basin is bordered on the west by the Livingston Range, on the east by the Lewis Range (Continental Divide), on the north by the McDonald Creek/Waterton River divide, and on the south by the Middle Fork of the Flathead River. Elevations range from about 3200 ft. (975 m), at McDonald Creek's confluence with the Middle Fork near West Glacier, to more than 9000

feet (2744 m), at the head of the drainage. Past mountain glaciers carved a relatively long, steep walled U-shaped valley, about 25 miles (40 km) long by 5 miles (8 km) wide. Lake McDonald, a glacial lake approximately 10 miles (16 km) long by 1.5 miles (2.4 km) wide, is a major topographic feature dominating the southern portion of the drainage.

The southwestern and south-central portions of the basin are occupied by relatively dense forests in the valley bottom and adjacent moderate- to steep lateral moraines (Howe and Snyder Ridges). Northeast of Lake McDonald, the continuous forest typically ends relatively abruptly in cliffs (timberline and alpine communities) after a steep ascent from the valley bottom. An estimated 60 percent of the basin's land area, primarily in the northern portion, consists of environments not occupied by post-fire seral age classes: riparian forests of black cottonwood (*Populus trichocarpa*) and spruce (*Picea englemanni x glauca*), avalanche (tall shrub) communities, uneven-aged and sparsely-to moderately stocked upper subalpine forests, krummholz, and alpine communities.

The remaining 40 percent of the area is densely forested primarily with lower subalpine forests (Pfister et al. 1977). At low and intermediate elevations in the southwestern portion of the study area (Apgar Mts. and vicinity), moderately young, densely stocked stands of even-aged lodgepole pine (*Pinus contorta* var. *latifolia*) and western larch (*Larix occidentalis*) regenerated after several very large fires in the early 1900s. The well-drained slopes and valley bottom within this area are characterized by cool-moist habitat types (Pfister et al. 1977), primarily subalpine fir (*Abies lasiocarpa*)/queenup beadlilly (*Clintonia uniflora*) [phases: *C. uniflora*, *xerophyllum tenax*]. Associated habitat types are subalpine fir/blue huckleberry (*Vaccinium globulare*), subalpine fir/beargrass, and subalpine fir/twinflower (*Linnaea borealis*). The canopies of older stands within these habitat types consist of long-lived larch dominating the canopy with the

associated uneven-aged, shade tolerant species subalpine fir and spruce (lodgepole pine generally persists in the stand for less than 150 years).

Near Lake McDonald, a narrow zone of relatively warm-moist habitat types exists between about 3200 and 3500 ft. (976-1067 m), primarily restricted to the bottomlands and lower slopes immediately adjacent to the lake (Habeck 1968). The study area's most structurally complex and floristically diverse stands are found in these western hemlock (Tsuga heterophylla)/clintonia and western redcedar (Thuja plicata)/clintonia habitat types [phases: clintonia and Aralia nudicaulis]. GNP's cedar/hemlock forest represents the most eastward extension of Pacific coastal forest types in the inland Northwest (Habeck 1968). The oldest stands are primarily uneven-aged, and are occupied by old large-diameter cedar and hemlock, with associates subalpine fir, spruce, Douglas-fir (Pseudotsuga menziesii var. glauca), western white pine (Pinus monticola) and, occasionally, grand fir (Abies grandis). These stands usually have an even-aged component of old larch persisting in the overstory, representing the first trees to occupy the site after stand-replacing fires. Relatively young stands in these habitat types are densely stocked with post-fire serals larch and lodgepole pine, in a largely even-aged canopy. The cedar/hemlock zone is rapidly replaced on the adjacent well-drained slopes by the even-aged larch/lodgepole or mixed-age larch/fir stands (cool-moist subalpine fir h.t.s.) previously described.

The transition from lower- to upper subalpine types occurs relatively rapidly above about 5500 feet (1677 m). Especially in the northern part of the study area, near Flattop Mountain, stands change to lightly- or moderately stocked uneven-aged spruce and subalpine fir (habitat types: subalpine fir/clintonia [beargrass phase] and subalpine fir/beargrass [blue huckleberry phase]). Throughout much of the study area, the continuous forest usually is replaced abru[illegible] precipitous slopes above about 6500 ft. (1982 m); small

krummholz stands of subalpine fir occupy a relatively narrow elevational zone before the transition to alpine communities at about 7000 ft. (2134 m.).

## Objectives

The study's overall objective was to determine fire frequency and fire's effects on forest succession over the past few centuries in the McDonald Creek basin. Specific objectives were to:

1. Prepare a stand age class map for the McDonald basin in order to provide information about the patterns of stand-replacing fires. The map also will be used to supplement GNP's Geographic Information System.

2. Assign regeneration (stand origin) years to the mapped tree age classes by increment boring.

3. Determine fire history by sampling fire scars, or by reconstructing age class chronologies for stands lacking fire scars.

4. Describe the effects of past fires on stand succession by documenting the tree species and age classes that survived fires and the species that regenerated in post-fire environments.

5. Prepare a final report which discusses fire history in terms of fire frequency, severity, burning (spread) patterns, and effects on forest composition and structure.

## Methods

The methods of Barrett and Arno (in press) were used to document fire history:

Sample Site Selection. In the office, potential sample sites were selected by examining GNP's 1945 and later aerial photographs. The goal was to select sample sites near the margins of adjoining age classes, to enable documentation

of as many even-aged stands (stand-replacing fires) as possible. The 1945 series (scale 1:12,500) provided the most useful photographs because the series better depicted the paths of large fires that burned in the early 1900s. The method was to first delimit the margins of the study area's even-aged stands on 7.5 minute topographic quadrangles (1:24,000 scale). Stands of apparently different age were identified through stereo photointerpretation, using tree crown texture, tone, relative height, and relative diameter as indices of relative stand age. Key (1983) documented the stand age class mosaic in the southwestern portion of the study area and adjacent drainages, and his map was used to select sample sites within that area. The selected increment boring sites were then marked on the 7.5 minute field maps which showed the preliminary margins of the study area's age classes.

Stand Sampling. The sample sites were next visited and re-evaluated by verifying the existence of fire-initiated even-age classes. At each acceptable site, the piths of 3 or more trees from each seral class were increment bored 1 foot (30 cm) above ground level. (Boring height was increased on heavily buttressed old trees if the borer could not penetrate the full radius of the tree at the 1 foot level). The increment cores were stored in plastic drinking straws, labelled, and transported back to the laboratory.

Age Class Analysis. The increment cores were mounted into slotted boards, sanded, and dated by counting the annual growth rings under magnification (7-25X binocular microscope). Estimates were made of the number of additional rings to the pith for any cores that did not precisely intersect tree centers (Arno and Sneck 1977).

Stand-initiation years (approximate years of stand-replacing fires) were estimated by establishing the following criteria: 1) similar pith years had to be obtained from at least 3 seral trees in the stand, 2) a maximum range of 20 years was considered acceptable for considering a group of similarly aged seral

trees to be within the same age class, and 3) the earliest pith year among a group of similarly-aged trees was considered to be an acceptable estimate of the stand-initiation year if more-reliable evidence, such as fire atlas maps or datable fire scars, was unavailable. No "growth factor", that is, the estimated number of years for the tree to reach the one-foot (30 cm) boring height, was assigned to the cores.

Age Class Mapping. After the stand-initiation years were estimated, a final age class map was developed for that portion of the study area not already covered by Key's (1983) map. This was done by editing, if necessary, the preliminary age class margins that were drawn on the pre-fieldwork maps. Four sources of evidence were used to produce the final map: the aerial photographs, the increment core data, GNP Fire Atlas maps depicting the years and extents of post-1910 fires, and Key's (1983) age class data.

For pre-1910 age classes (i.e., undocumented fires), the sample locations and stand initiation years were first labelled on the maps. Then, using the aerial photographs, the age class that represented a given sample stand was traced to its furthest extent in the study area by following the appropriate aerial photograph flight lines. Age class margins were adjusted to the 7.5 minute scale by using topographic reference points, that is, by following contiguous land features such as ridgelines and dendritic stream drainage patterns.

The following method was used when unsampled age classes were encountered on the photographs, as in the case of very remote or inaccessible areas. It was necessary to: 1) extrapolate known dates from the nearest sampled age classes of similar crown appearance, or, when extrapolation was not appropriate, 2) assign relative-age labels (e.g. "pre-1850") to the unknown age class by comparing its crown texture to that of the nearest stands whose ages were known.

*Fire Frequency Analysis*. To produce the Master Fire Chronology and estimate stand fire frequencies, relatively continuous sampling transects also were run throughout the study area along roads and trails. The goal was to locate fire-scarred trees and continuously document the even-age classes. Upon locating scarred trees, the plan was to use an increment borer to bore fire scars and estimate the fire years (Barrett and Arno [in press]).

Stand age class chronologies were reconstructed for even-aged stands that did not have fire scars. The method was to first estimate the stand-initiation year for the current stand by increment boring (previously described). Next, any remnant seral trees from the site's previous age classes, largely destroyed in the last stand-replacing fire, were bored to estimate their stand-initiation years (similar pith years were necessary from at least 3 remnant trees). For example, scattered snag-top survivors, representing the fire's snag age class, often can be found throughout the burned area.

Frequency of stand-replacing fires occurring within ecologically similar stands was next calculated by estimating the number of years between the successive fires (represented by the estimated ages of the successive age classes). Mean fire interval (MFI) also was calculated for any sites that had evidence of 3 or more fires (i.e., at least 2 fire intervals). Otherwise, a multiple-site average fire interval (MAFI) was calculated for those sites that had evidence of only one fire interval. MAFI is calculated by first totalling the single fire intervals found for each stand within a network of ecologically similar stands, then dividing by the number of intervals. Median fire interval also was calculated for these stands by ranking the intervals according to year length, then determining the mid-point value.

*Stand Structure Analysis*. To document fire effects, tree succession was documented by inventorying one or more macroplots (375 $m^2$) within each sample stand. In each macroplot, ocular estimates were first made of the tree

species' canopy coverages according to 4 dbh classes (0-4", 4-12", 12-30", 30+"). To characterize stand age structure, cores were taken from 2 or more of the largest-diameter trees within each dbh class (these data supplemented those already taken from the stand's seral age classes). The plot data were then compiled in the office by graphing each tree species' canopy coverage by dbh class. When more than one plot was taken in a stand, a composite graph was developed by averaging the plot canopy coverages and maximum tree ages for each diameter class. Finally, interpretations about post-fire tree succession over the last several centuries were derived by examining each stand's tree graph and tree ages relative to the stand's Master Fire Chronology.

## Results

<u>Study Area Age Class Mosaic</u>. Forty-six sample stands were visited in the McDonald Creek basin and adjacent areas (lower Camas Cr., Apgar Range). Pith years from 139 seral trees (120 western larch, 19 lodgepole pine) revealed 18 different age classes for the pre-1910 period (Appendix). Western larch was the favored sample species because of its longevity; in terms of maximum tree (age class) ages, most larch stands were between 250 and 350 years old, and the oldest class was 470 years old. The oldest lodgepole pines, a relatively extensive age class in the lower Camas Creek drainage and northward (Key 1983), reached about 121 years before being killed in a recent mountain pine beetle (<u>Dendroctonus brevicomis</u>) epidemic (Armour 1982).

The moderate number of sample trees illustrates a number of important facts about the McDonald basin's fire history. First, most stands in the study area contain just one seral age class, and 3 trees usually were adequate to document an age class. Second, the basin's age class mosaic is composed of seral age classes which regenerated after a relatively few large fires (fewer sample sites were needed because of age class redundancy). Third, most of the seral

age classes are found in the southern and south-central portions of the study area (i.e., lower subalpine zone)--nearly one-third of the study area, mostly in the northern portion, did not contain evidence of long-term fire history (i.e., uneven-aged stands occupy the upper subalpine zone). Fourth, stands within about 50% of the lower subalpine zone were replaced by well documented large fires in this century (sampling was conducted within these areas only if there were remnants of previous age classes).

The most-useful fire history data were obtained from the study area's old growth larch stands, which exist in the south-central portion of the study area (e.g., mid- to northern Howe and Snyder Ridges). These age classes comprise a relatively contiguous block of about 36,000 acres (14,575 ha)(fig. 2). In fact, few seral age classes exist north of the Avalanche Creek drainage. For example, immediately north of that tributary, McDonald Creek flows through a narrow steep-walled canyon for about 6 miles (10 km). The canyon contains numerous large avalanche chutes interspersed with patchy uneven-aged stands surrounded by outcrops and cliffs, and the canyon bottom is dominated by riparian stringer stands. There is virtually no scar- or seral age class evidence in this portion of the basin, suggesting that fire has played a relatively limited role as a disturbance agent. The highly variable vegetation mosaic, including the moist and relatively non-combustible <u>Alnus sinuata</u> avalanche swaths, in combination with the surrounding topographic barriers, evidently severely limits fire's ability to spread and consequently dictates smaller fires than occur along the continuously forested moraines adjacent to Lake McDonald.

The McDonald basin again widens to a broad glacial valley northwest of Alder Creek (fig 2). However, fire history evidence also is limited in the upper basin because the forest is in transition to the upper subalpine zone. The moist stands in this area generally are occupied by lightly- to moderately well

stocked spruce and subalpine fir. Mean annual precipitation near Flattop Mountain is about 60 inches (152 cm)(Finklin 1986), moreover, fires cannot readily spread into the upper basin because it is bordered by alpine ridges and the rocky gorge between Avalanche and Alder Creeks. Seral age classes exist on only a few southerly aspects below about 5500 feet (1677 m), the approximate upper limits of western larch. Here, remnants of an old larch stand were sampled along the margins of a lodgepole pine age class which regenerated after a 1936 fire in the Granite Park area (fig. 2).

Fires During the Post-1910 Period. Fire occurrence records have been maintained for much of GNP since the park's inception in 1910. Compared to other areas of the Northern Rockies, GNP's west-side forests have experienced unusually frequent stand-replacing fires during this century.

The study area's last significant fires occurred during the severe 1967 fire season. Stands on about 8855 acres (3585 ha) were replaced during the Flathead Fire, in the northwestern portion of the Apgar Range (fig. 3). During that same fire season stands on 3109 acres (1259 ha) were replaced during the Glacier Wall Fire, in the north-central portion of the study area (fig. 2). After smoldering for several days, this fire made relatively large stand-replacing runs through the tree canopy. Aggressive suppression measures, including bulldozers, were used on both of the 1967 fires.

In 1936, the Heaven's Peak Fire replaced stands on about 3000 acres (1215 ha) of the Granite Park basin and adjacent areas. This severe fire (discussed later in this report) is especially noteworthy because it crossed the precipitous Continental Divide and replaced stands on an additional 5800 acres (2348 ha) of the park's east side.

The GNP Fire Atlas and Key's (1983) age class map indicate that a number of large fires also occurred in the southern portion of the basin during the early 1900s. Stands were replaced over tens of thousands of acres in the park, as

well as on adjacent non-park lands in the Middle Fork and Flathead River canyons (figs. 2 and 3, Appendix). The 1929 Half Moon Fire, for example, began as an escaped slash fire about 8 miles (13 k) southwest of GNP's southwestern boundary. This fire burned 6696 acres (2711 ha) within the southern Apgar Mountains and Belton Hills; however, stands on an additional 33,345 acres (13,500 ha) also were replaced in the adjacent Hungry Horse and lower Middle Fork canyons, for a total burned area of 40,041 acres (16,211 ha). The 1926 Apgar Fire, also human-caused, burned 4799 acres (1943 ha) in the south-central to northern Apgars. Two fires occurred in the Apgars in 1925, one human-caused (1600 acres [648 ha]), and one lightning-caused (2248 acres [910 ha]). Finally, in 1919 about 1279 acres (518 ha) burned near Trout Lake, in the north-central Camas Creek drainage.

Key's (1983) age class map shows that all of these early-day fires had spread in large stand-replacing runs. Field sampling revealed that the few small old growth stands that remain between the burns' margins usually are less than 100 acres (41 ha) each, and the stands are highly scattered and heavily scorched and thinned by fire. As a result of this severe-fire pattern, multiple-fire-scarred trees generally do not exist within the McDonald basin forests.

The Apgar Range is particularly interesting in terms of post-1900 fires. This small, southeast-to-northwest oriented range comprises a major topographic divide southwest of Lake McDonald, and the ridgeline evidently receives a disproportionately high number of lightning ignitions when storms enter the park from the southwest (Key 1983). Virtually the entire approximately 34,000 acre (13,733 ha) area was burned by just 3 stand-replacing fires between 1926 and 1967 (fig. 3): 1) the northern third of the range was burned in the 1926 Apgar Fire, 2) the southern third of the range was swept by the Half Moon Fire 3 years later, and 3) about a quarter of the range, the western and

northwestern portion, burned in the 1967 Flathead Fire. The latter fire was one of the few west-side fires on record to escape the park and burn adjacent land (193 acres [78 ha] on the Flathead National Forest). Old growth sampling opportunities within the Apgars were limited to: 1) the scattered small stringer stands that did not burn, primarily in moist draws, 2) one moderate-size, unburned old larch stand near lower Fern Creek, and 3) to the few remaining old snag-top larch within the current 60-year old canopy.

For the period between 1910 and 1983, Key (1983) found that human-caused fires had burned nearly as many acres on the park's west side as those attributable to lightning fires. All of the fires were stand-replacing fires, therefore human-caused and lightning ignitions have contributed nearly equal acreage to the currently young forest mosaic that exists primarily in the southwestern portion of the McDonald basin.

In summary, there were 9 large fires in the study area between 1910 and 1987, and they all had spread by making large stand-replacing runs. These fires burned about 36,301 acres (14,697 ha): 1) this acreage equals an estimated 50% of the lower subalpine forest zone (the primary focus of study), and 2) young age classes cover a large and relatively contiguous area of the Apgar Mountains, southern Howe and Snyder Ridges, the Belton Hills, and tens of thousands of acres of adjacent non-park lands to the south.

Fires During the Pre-1910 Period. Sixteen pre-1910 age classes, representing past stand-replacing fires, were documented based on the aerial photographs and field sampling. Two patterns emerged from the data on old growth forests (fig. 2, Appendix). First, most of the old growth mosaic is composed of a relatively small number of different aged stands which are generally between 250 and 360 years old (maximum age sampled: 470 yrs.). Second, the old growth stands cover a moderately large and contiguous area of the south-central [illegible] central portion of the McDonald basin. For example, the

age class map (on file: GNP Research Division) shows an abrupt boundary between the study area's young and old stands, along southern Howe and Snyder Ridges (fig. 2). The Avalanche Creek area represents the most northerly extent of this contiguous old growth (lower subalpine) forest.

The Master Fire Chronology (Appendix) suggests that there was a relatively fire-free period, in terms of moderate- to large fires, between about 1735 and 1919. For this nearly 2 century period, there is evidence of only 2 moderate-size age classes: 1) a 1798 class, about 3000 acres (1215 ha), near lower Fern and Fish Creeks, and 2) an 1813 class, about 1200 acres (486 ha), along south-central Snyder Ridge. The 11 remaining age classes that became initiated after fires during this period appear to be less than 500 acres (202 ha) each. The large post-1900 fires may have destroyed some fire history evidence for this time period, but even within the most severely burned areas old sample trees were abundant enough to provide a relatively continuous record of fires on the site.

Age class data from this study (Appendix), and data for 2 sample stands from GNP Cartographer C. Key (data on file), indicate that a large proportion of the McDonald basin's old growth stands became initiated shortly after 1735. Closely similar pith years from 49 larch obtained from 17 well-dispersed sites suggest that these stands regenerated after one large fire, or, after several relatively large fires within a short period (fig. 2). This "1735" class was found at 37 percent of the 46 sample sites, and comprised 35 percent of the study's sample trees. It was not possible to derive a more precise estimate of fire year(s) for the "1735" class because no datable fire scars could be found for sampling. The 49 pith years that were grouped into this class ranged from 1735 to 1754; 34 of the 49 pith years preceeded 1750 and the remaining 15 samples ranged up to 1760 (4 of these 15 trees slightly exceeded the previously defined 20-year range for an age class but the trees were still grouped into

the 1735 class because nearby sample trees dated to the early 1740s).

The 1735 age class was sampled along the northwest, northeast, and southeast sides of Lake McDonald, from the lakeshore to the tops of Howe and Synder Ridges (fig. 2). The stand margins, however, usually are difficult to follow on the aerial photographs because of the contiguity of the 1735 and 2 older classes. (Aerial photographs are only marginally useful for tracing the margins of adjacent old growth stands because the canopies of stands older than about 200 years appear relatively homogeneous). Along northern Howe Ridge, for example, an apparently large portion of the 1735 class adjoins two possibly large classes which regenerated after fires in about 1671 and 1628 (these classes also occupy the mid-Camas Creek drainage). Likewise, along northern Snyder Ridge another large portion of the 1735 class adjoins a 1780 class that occupies much of the ridgetop and portions of the adjacent Lincoln Creek drainage (Barrett's [1986] Middle Fork study area). And further north, near the head of Lake McDonald and John's Lake, the 1735 class adjoins an apparently moderate-size 1769 class.

Evidence of the 1735 age class, or of any other seral age classes, could not be found within the narrow McDonald Creek canyon (which contains uneven-aged and avalanche communities, previously described). However, the 1735 class was again encountered near Packer's Roost, where the upper basin widens: 3 snag-top larch, between the margins of the 1936 burn, dated to about 1740. The most northerly evidence of the 1735 age class, which also represented the most northerly seral classes, was found at 2 sample sites along the lower Loop Trail and near the junction of McDonald and Mineral Creeks (base of Flattop Mountain ridge). This area is a transition zone between the lower and upper subalpine forest, and there is a relatively abrupt change from even-aged western white pine/larch- or lodgepole pine stands to uneven-aged spruce/fir stands. Increment borings of the maximum ages of uneven-aged stands along Flattop

Mountain ridge indicates that the spruce/fir stands often exceed 200 years, suggesting that the 1735 fire(s) might well have burned into some these upper subalpine forests.

Only a rough impression can be gained of the overall extent of the 1735 class in the study area. The estimation method was to examine the aerial photographs, for any apparent stand margins, in conjuction with the field map which displayed the locations of sample sites indicating that class. In total, the age class appears to occupy as many as 20,000 acres (8097 ha) in the McDonald basin, but this undoubtedly is a conservative estimate of the actual burned acreage because some age class evidence may have been destroyed by subsequent fires. This acreage estimate equals about 27 percent of the study area's lower subalpine zone, and more than 50 percent of the basin's old growth forest. The largest relatively contiguous portion of the age class appears to be about 6000+ acres (2429 ha) along the southeast-facing slope of northern Howe Ridge, adjacent to Lake McDonald (fig. 2).

The study area's oldest seral age classes, larch which regenerated after about 1517, were found in 2 relatively small non-adjacent stands: 1) along the northeast-facing slope adjacent to Avalanche Lake, and 2) near lower Logan and Haystack Creeks (fig. 2). These stands are now highly uneven-aged and heavily dominated by large-diameter spruce, subalpine fir, and western hemlock, and only a few old larch persist in the overstory. It was possible to derive only very approximate estimates of the pith years for 5 larch because all of the trees were heavily buttressed near ground level. The pith years at breast height ranged from 1517 to 1527, and it is unclear whether the 2 stands regenerated after the same fire season or after 2 fires occurring within a relatively short time period.

In summary, the McDonald basin's lower subalpine age class mosaic can be grouped into 2 categories, distinct in age structure and in geographic

location: 1) about 50 percent of the lower subalpine forest consists of lodgepole pine/larch stands less than 60 years old, and these are located mostly in the southwestern portion of the study area; these stands regenerated after several large fires in the early 1900s and in 1967; 2) the remaining nearly 50 percent of the lower subalpine zone, primarily in the south-central and northern portions, is occupied by old larch/fir and cedar/hemlock/larch stands between about 250 and 360 years old; a very large fire in about 1735, or a short period of relatively large fires, produced about half of this old growth acreage (no evidence of the extensive 1735 age class was found in the southwestern portion of the study area).

Fire's Effects on Stand Succession. Forty-eight macroplots were tallied within the 46 sample stands. One macroplot usually was adequate for characterizing stand tree composition and age structure because the study area lacks habitat type diversity and the area has had a predominant pattern of stand-replacing fires (hence a similar pattern of post-fire stand succession). All of the macroplots that were taken well between a given burn's margins contained one seral age class, and these trees invariably were the oldest trees in the stand because they were the first trees to occupy the site after the stand-replacing fire. Conversely, 2 seral classes usually were found along burn margins (i.e., margins of adjacent classes). Trees bearing large basal scars from the most-recent fire generally were found only along these burn margins, or, on the highly scattered survivors within the burned area. In general, the stands did not contain scars older than those inflicted by the most-recent severe fire, evidently because the long fire-free intervals, the severe fire pattern, and the moist (decay-inducing) site conditions make it unlikely that a chronology of fire scars from successive fires will be retained on the site. This fire-scarring pattern differs markedly from that in the

North Fork study area (Barrett 1983), where the lower-elevation stands experienced periodic non-lethal surface fires before the eventual occurrence of a stand-replacing fire (multiple-scarred trees are widespread in that area).

The McDonald basin's forests are characterized by relatively abrupt transitions between the lower- and upper subalpine zones. Consequently most of the fire evidence, hence most sampling, occurred within only a few habitat types, primarily subalpine fir/clintonia and western redcedar/clintonia. Stand plots show that in the early- to mid successional stages, both habitat types are characterized by densely stocked stands with a dense even-aged overstory of lodgepole pine and larch. In the subalpine fir habitat types western larch is the sole seral survivor dominating the canopy during later successional stages, and uneven-aged spruce and subalpine fir share dominance (fig. 4). Post-fire succession is generally comparable within the cedar/hemlock habitat types except that there usually is an increase in tree densities and species diversity within old stands (fig. 5). Long fire-free intervals on these more-moist sites allow cedar and hemlock to dominate the overstory, and larch is often only a minor co-dominant.

Fire Frequencies. The dearth of useful fire scars made it necessary to reconstruct age class chronologies--data from fire-initiated regeneration representing successive stand-replacing fires on a site (Barrett and Arno [in press]). These chronologies provided the sole means of calculating fire frequencies, and the frequency interpretations below apply mainly to the lower subalpine zone because the fire history evidence existed within that area (upper subalpine fire history is discussed later in this report).

The Master Fire Chronology spans the period from 1517 to 1987 (470 yr) (Appendix). There were 23 fire years, but 26 known fires (i.e., there were 2 fires in 1910, 1925, and [illegible] respectively), yielding an MFI of about 19 years

for the McDonald basin study area. That is, a spreading fire occurred somewhere in the 98,000 acre area on an average of every 19 years between 1517 and 1987. Sampling probably fails to detect some relatively small fires, so these would not be represented in the Master Fire Chronology.

Fire frequency also was calculated for the pre- and post-1910 periods: 1) there were 7 fire years, but 10 separate fires, between 1910 and 1987, for a study-area MFI of about 9 years; 2) 16 fire years were documented for the pre-1910 period (1517-1910), for a study area MFI of about 26 years. Fires appear to have been more frequent during this century, but there are several possible reasons for the discrepancy. First, it is difficult to make meaningful comparisons between the 2 time periods because the year lengths differ greatly (i.e., 77 yrs. vs. 393 yrs.). Second, some pre-1735 fires, especially relatively small ones, may not have been detected because they could have been destroyed in the 1735 fire. The occurrence of 3 human-caused fires after 1910, co-incident with severe regional droughts, might explain the possible increase in fire frequency during this century. Conversely, inadequate archaeological information exists about any past Indian use patterns that might be used to speculate about human-caused fires before 1910 (Barrett 1983, Gruell 1985).

It was possible to develop age class chronologies for 11 of the 46 stands, that is, only 11 sites produced evidence of successive stand-replacing fires. Results suggest that stand-replacement intervals ranged from 131 to 450 years (table 1), but replacement usually occurred after 150 to 250 years of stand development (8 of 11 stands). It was not possible to calculate mean fire intervals for stands because none of the sites produced evidence of 3 or more successive fires. Consequently the 11 sites' single fire intervals were totalled, then averaged, yielding a multiple-site average fire interval (MAFI) of 226 years. The median fire interval was 201 years (table 1).

The data for age class chronologies are too limited to detect any

substantial differences in fire frequency between the 2 major habitat types (subalpine fir/clintonia; western redcedar/clintonia). Table 1 suggests a possible trend toward shorter fire intervals in the less moist subalpine fir and spruce habitat types (e.g., subalpine fir/dwarf huckleberry [Vaccinium caespitosum]): stands 34 and 35 in the southern Apgars had stand-replacement intervals of 131 years and 150 years, respectively. In contrast, longer fire intervals might be suggested for the more moist cedar/hemlock types in the mid- to northern portion of the study area: stands 39 and 42 near Avalanche Lake and lower Alder Creek had stand-replacement intervals of 344 years and 450 years, respectively. However, when the 2 very long fire intervals in table 1 are removed from consideration, the interval ranges were closely similar among the study area's 2 major habitat types: the subalpine fir/Clintonia interval range was 131 to 252 years, while the western redcedar/Clintonia range, not including stands 39 and 42, was 145 to 255 years.

The fire history pattern for the McDonald basin (i.e., long interval/stand-replacement fires) is strikingly similar to that within the adjacent Middle Fork of Flathead River drainage. Barrett (1986) found comparable fire intervals for 10 sample stands in the Middle Fork: 1) stand-replacing fires usually occurred at intervals of 150 and 300 years on a given site, 2) the MAFI for 6 stands was 211 years, and 3) the median fire interval was 198 years (MAFI/median for the McDonald basin: 226/201 yrs).

Upper Subalpine Zone Fire History. There was little evidence of long-term fire history in the upper subalpine forest because there were few seral age classes and fire scars. Interpretations about fire frequency and burning patterns are still possible, however, by examining several sources of information: 1) the GNP fire atlas, which portrays relatively recently burned areas, 2) data from this study's northernmost sample stands, and 3) a written

account of a fire that occurred in the early 1900s (McLauglin 1978). Two large stand-replacing fires have occurred in the upper McDonald basin in this century--the 1936 Heaven's Peak Fire and 1967 Glacier Wall Fire. A Fire Atlas spread map and McLauglin's (1978) description of the 1936 fire were helpful in interpreting fire behavior and effects within the upper subalpine forest types adjacent to the Continental Divide. Age class chronology data from 4 stands within and adjacent to the 1936 and 1967 burned areas also suggested possible replacement frequencies for the transition zone between the lower and upper subalpine forest zones.

Lightning ignited a fire near the northeast corner of the precipitous Glacier Wall in 1936, at approximately 5200 feet (1585 m) elevation (fig 2). The north-facing stands adjacent to the burned area today are moderately well stocked with uneven-aged spruce and subalpine fir. The fire smoldered and crept for 12 days before high winds caused it to crown, burn downslope, and cross McDonald Creek. The fire, still crowning, then swept upslope into Granite Park, which is a subalpine basin composed of even-aged lodgepole pine stands that rapidly thin to krummholz at about 6000 feet (1829 m). The fire then spread from the continuous forest to the krummholz zone by means of wind-blown embers. After burning about 3000 acres (1215 ha) within the McDonald basin, these "firebrands" enabled the fire to rapidly cross the cliffy Continental Divide through Swiftcurrent Pass. The fire continued to spread eastward into the Swiftcurrent Valley by making repeated upslope runs on the valley walls. McLauglin (1978) was a seasonal park ranger in the Swiftcurrent Valley during this time and he described the fire's dramatic crossing of the Continental Divide:

> "At 8:45 on the evening of September first...as my party of hikers topped the rise of ground separating Swiftcurrent Lake from Lake Josephine an occasional flake of ash settled ....As we emerged [illegible] the margin of Grinnel Lake, the ash was raining down....The wind was blowing strongly from the west bearing

more ash and branches, still glowing as they hissed into the water. The acrid air filled our lungs and made the eyes water....I pointed to the precipitous Garden Wall [Continental Divide] rising precipitously four thousand feet from the valley floor [and said to my hiking party], "There's no way the fire can cross over that wall." I hoped I had sounded convincing....Dusk was deepening [and] we became aware of a glow in the sky near the summit of Swiftcurrent Pass....Suddenly, to our utter amazement, a tree near the summit on the east side of the pass caught fire and blazed against the night sky like a fiery cross....All at once a tree lower down caught [and] the entire flank of Mt. Wilbur became a racing sheet of flame..." (McLauglin 1978: 8-10).

The fire thus burned an additional 5800 acres (2348 ha) of krummholz and continous lodgepole pine on the park's eastside. (Limited suppression action was taken on this fire, but it apparently was largely ineffective).

This extreme fire behavior well illustrates fire's potential during a period of strong winds and prolonged drought. The pith years of 3 remnant larch sampled within and adjacent to the burn's lower margins indicate that the fire replaced primarily the 1735 age class (201 yrs), and no older trees were found within the upper Granite Park basin (upper subalpine forest zone). Interestingly, in the Middle Fork study area, Barrett (1986) found that a large fire in 1910 had successfully crossed the rocky alpine communities along Firebrand Pass and spread downslope into the adjacent lower-elevation forest (this was interpreted from sampling since the GNP fire atlas did not have a map of the 1910 fire in that area).

The 1967 Glacier Wall fire also was ignited by lightning, within a short distance of the 1936 ignition area (fig. 2). The ignition occurred on a lower slope (approx. 3600 feet [1098 m]) above McDonald Creek, evidently in a lightly stocked, uneven-aged stand of spruce and subalpine fir. The fire smoldered briefly before making several relatively large stand-replacing runs up the steep southeast face of the Glacier Wall. A portion of the fire then spread northeast, spotted across a bulldozer line, and crossed McDonald Creek. The

fire swept uphill into Granite Park, roughly adjacent to the 1936 fire's southeast margin. The fire atlas shows that most of the fire's 3109 burned acres (1259 ha) occurred over 7 days, and that individual stand-replacing runs usually were less than 300 acres (122 ha) each. Unlike the 1936 fire, however, the 1967 fire apparently stopped at the upper limits of the continuous forest. Aggressive suppression measures were used on this fire, in fact, the map shows that a fire line represents the fire's upper margin. Thus the fire might well have spread further into the upper basin, similar to the 1936 fire, if no suppression had occurred. The record shows that both fires occurred during similarly extreme burning conditions (i.e., prolonged drought, strong winds). Stand sampling suggested that the maximum stands ages at the time of replacement in 1967 were 232 and 450 years (1517 and 1735 classes), but the fire also burned about 400 acres (162 ha) of 1936 regeneration (31 yrs).

In summary, the stand-replacement fire intervals found for stands along the ecotone of the lower- and upper subalpine forest were roughly similar to those found in the study area's lower elevations. An exception is the 450-year fire interval mentioned above, which is the study's longest (table 1). Intense and rapidly spreading fires periodically are generated within the lower elevation forests, especially on steep terrain when drought and high winds coincide. The 1936 Heaven's Peak fire well illustrates the most extreme type of stand-replacing fires--ones that can burn into and spot across cliffy alpine terrain. During less extreme burning conditions, however, the upper elevations' sparse and discontinuous fuels usually halt the spread of lower-elevation crown fires, and sparse alpine fuels also inhibit the spread of fires occurring within that zone (Arno 1980). For example, in the Middle Fork study area (Barrett 1986), stand sampling on the east- and west sides of Two Medicine Pass indicated that the area's most recent stand-replacing fires had burned to the heads of the opposing Park Creek and Paradise Creek drainages, but did not successfully

cross the Continental Divide.

*Role of Fire Suppression*. The GNP Fire Atlas and data from Key (1983) were used to analyze the occurrence of post-1910 fires in the McDonald basin. The goal was to examine all recorded ignitions which had occurred in the study area between 1910 and 1987. Unfortunately, the record is incomplete because some fire reports have been either misplaced or discarded (pers. comm. with W. Colony, GNP Fire Management Officer). Specifically, occurrence data are not available for the upper portion of the McDonald basin, north of about Avalanche Creek (primarily upper subalpine zone).

For the southwestern portion of the study area, Key (1983) found that Howe and Apgar Ridges each received 66 lightning ignitions between 1910 and 1982. While ignitions were relatively frequent in this vicinity, there were significantly fewer class B+ (>.26 ac.) fires along Apgar and Howe Ridges than along the somewhat drier ridge systems to the north (North Fork valley). This ignition frequency results in an average of about 21 class B+ ignitions per decade in the Apgar/Howe Ridge area.

For the Snyder Ridge area (southeast of Lake McDonald), the Atlas suggests that substantially fewer ignitions have occurred than along Apgar and Howe Ridges. An occurrence map indicates that 27 class A (<.25 ac.) ignitions, including those from human causes, were suppressed in the area from Snyder Ridge to the head of Lake McDonald (including upper Sprague and Snyder Creeks). Ignition frequency thus equals about 3 ignitions per decade (no fires larger than class A have occurred over the last 77 years).

Two ignition patterns are evident for the Snyder Ridge area. First, 14 of the 27 ignitions (52%) were human-caused fires near the McDonald lakeshore campgrounds. Second, the 13 remaining lightning ignitions occurred within the middle- and upper elevations along Snyder Ridge and the upper Sprague Creek

drainage. All 27 fires occurred within the 1735 or older age classes.

The historic range of fire intervals in Table 1 suggests that, throughout the past 78 years of the Fire Suppression Period, the old growth stands along Snyder Ridge would have presented favorable fuel conditions for the development of spreading fires during drought periods. Severe regional droughts have occurred within this century: 1) during a number of fire seasons between about 1910 and the mid-1930s, and 2) in 1967. (The park's largest fires have in fact occurred during both periods). The occurrence map for Snyder Ridge, which lists ignitions by decade, shows that 18 of the 27 ignitions (67%) were suppressed in the old growth forests between 1910 and 1940, and no ignitions occurred in 1967. Otherwise, most ignitions which occurred in these moist forests during non-drought years probably had little potential to develop into significant spreading fires.

## Discussion

The McDonald basin's fire history pattern is similar to that of the adjacent Middle Fork drainage. First, the ecologically similar stands in both areas have experienced primarily long interval/stand-replacing fires over the last 3 to 5 centuries. Second, non-lethal surface fires have not been characteristic in the areas' moist habitat types. Third, moderately large- to very large fires have been the predominant pattern. Fourth, the forest mosaic within both areas currently is occupied by a similar proportion of either moderately young- or relatively old age classes; there are comparatively few middle-age stands (i.e., between 100 and 200 yrs.) in both areas. Fifth, both areas have a highly grouped arrangement of young and old age classes on the landscape, rather than an intricately mixed distribution. Finally, in both drainages large expanses of moderately young stands occupy both sides of the GNP boundary, a result of severe fires in 1910 and 1929.

The North Fork study area had a substantially different fire history pattern. Multiple-scarred trees were found in nearly all 20 of Barrett's (1983) sample stands, as well as along the continuous sampling transects. Mature lodgepole pines usually had from 1 to 3 fire scars each, and the old growth larch and ponderosa pines had from 3 to 7 scars each. This indicates that non-lethal surface fires occurred 1 or 2 times during the life of a given lodgepole pine stand, and up to 7 times in the old larch/Douglas-fir/ponderosa pine stands, before the eventual occurrence of stand-replacing fire. Consequently, fire frequencies were substantially shorter in the North Fork. Surface fires generally occurred every 25 to 60 years, and stand-replacing fires ranged from 100 years (lodgepole pine stands) to as many as 300 years (old larch stands). Very large fires have occurred in the North Fork but there was a different pattern than that in the McDonald basin and Middle Fork: stand replacement burning often was highly patchy and disjunct in the lower elevations on broad and gentle slopes (i.e., stand replacing fire alternating with surface fire). Conversely, stand replacement was relatively continuous in the steeper higher elevations. Key's (1983) forest mosaic map, which extends from the Canadian border to Howe Ridge, reveals a highly complex mosaic of relatively small stands in the North Fork (often less than 200 hundred acres each). The forest mosaic becomes progressively less intricate with southward progression from the North Fork to the more moist (Finklin 1986) McDonald basin and Middle Fork areas. The North Fork's drier habitat types and less steep topography seem to be important factors contributing to its different fire history pattern.

In terms of study area Master Fire Chronologies, all 3 study areas apparently experienced relatively long fire-free periods over the last 3 centuries. For example, few large or moderate-size fires occurred in the McDonald basin over the 184 years between 1735 and 1919 (previously described).

The Middle Fork experienced a similarly long fire-free period during about the same time. Specifically, a relatively large stand-replacing fire occurred in the Middle Fork in about 1673, and the next widespread stand-replacing fire occurred about 107 years later in 1780. This was followed by another relatively fire-free period of about 150 years, then, tens of thousands of acreas were replaced by the large fires in 1910 and 1929. In the North Fork study area, 3 apparently large stand-replacing fires occurred between 1655 and 1683. This period was followed by a relatively fire-free period of about 161 years, then stands over tens of thousands of acres were replaced by large fires in 1844, 1869, 1889, 1910, and 1926 (Ayres 1900, Barrett 1983, Key 1983).

When the fire occurrence data for all 3 study areas are viewed in the context of one large area (GNP's west-side forests), 3 patterns are apparent: 1) there possibly has been only one severe fire year common to all 3 areas over the last 3 centuries; relatively widespread fire scar- and stand-initiation years were found for the years 1667, 1671, and 1673 and this might suggest the same fire year, 2) during this century several severe fire years occurred in at least 2 of the 3 study areas (1910, 1926, 1929), and 3) over the last 3 centuries the west-side forests have experienced 4 relatively long, fire-free intervals, ranging in length from 107 to 184 years (mean: 150 yrs)--this recurrent pattern seems to support the fuel succession/fire cycle models (Bevins 1979, Jeske and Bevins 1979, Armour 1982) that have been developed for GNP's lodgepole pine forests.

The similarities in fire history between the McDonald basin and the Middle Fork suggest that similar fire planning strategies would be appropriate, but only from the standpoint of fire behavior and vegetative succession. Planning must also account for socio-political concerns, and the human use patterns are substantially different between the heavily travelled McDonald Creek basin and the lightly used Middle Fork.

In terms of planning for natural fires in the McDonald basin, GNP managers can expect potentially large stand-replacing fires to occur during severe burning conditions, especially within the nearly contiguous zones of old-growth stands. The historic fire intervals and fuel models (Jeske and Bevins 1979, Armour 1982) suggest that the old growth stands are substantially more flammable than the moderately young lodgepole pine stands. Jeske and Bevins (1979) developed fuel models for "mesic" and "xeric" sites (i.e., cedar/hemlock vs. lodgepole stands). Both types showed strong tendencies for the total fuel load to increase over time, usually beginning 2 or 3 decades after the initially heavy fuel loadings created by snags from the stand-replacing fire. Fire behavior modeling (Bevins 1979) suggested that potential rate-of-spread, scorch height, and fire intensity (KCAL/$m^2$/sec.) also increased over time in both types of stands but potential spread rate, for example, was 50 percent greater for stands 155+ years old than for stands less than 55 years old. Armour's (1982) findings for mountain pine beetle-killed lodgepole pine stands in the North Fork also suggested that the heaviest fuel loadings are acheived about 100 to 150 years after stand initiation, that is, when the fallen snags intermingle with the dense canopy of maturing spruce and fir.

The age class maps, which portray the locations of the study area's oldest stands, might be useful in estimating where the next stand-replacing fires will occur. For example, Synder Ridge, and the forests occupying the area between Howe Ridge and the mid-Camas Creek drainage, contain the largest acreages of contiguous old growth forest on the park's west side. The sample stands in these areas are now between about 250 and 360 years old (1735 and 1628 classes), and the stands currently are near or beyond the historic maximum stand-replacement intervals. Moreover, the old stands in the Howe/mid-Camas area now adjoin many thousands of acres of contiguous lodgepole pine snags, produced by the recent mountain pine beetle epidemic.

Key's (1983) and Barrett's (1986) age class maps suggest other implications for GNP fire management. Virtually the entire Apgar Mountains/lower Middle Fork area, on both sides of the GNP boundary, is occupied by moderately young age classes (less than 60 years old). Lightning ignitions occur frequently on Apgar Ridge (Key 1983), but the historic fire intervals and fuel models (Jeske and Bevins 1979, Armour 1982) suggest that fire risk currently is not high in the area's stands.

The large and contiguous acreage currently occupied by these relatively less-flammable stands also presumably minimizes the fire risk in terms of escaped fires spreading to adjacent non-park lands. The 1929 age class, for example, covers tens of thousands of acres on both sides of the park's southernmost boundary. GNP's westside fire studies (Armour 1982, Barrett 1983, Key 1983) suggest instead that the North Fork valley will be more prone to large escaped fires. The recent mountain pine beetle epidemic in that area killed most of the mid- to late 1800s lodgepole pine stands on both sides of the park boundary and the fire risk is expected to increase markedly over the coming decades (Armour 1982).

## CONCLUSION

Fire suppression evidently has only been partially effective in GNP. As elsewhere in the West, many lightning and human-caused ignitions have been extinguished during this century. But in GNP's west-side forests most ignitions clearly have little potential to develop into significant fires because ignition frequently does not coincide with severe fire weather. When ignition, high-risk fuels, and severe weather do coincide, experience indicates that even the most aggressive suppression measures are often ineffective, or, might only succeed in reducing the eventually large acreage of a fire.

Unlike many other national parks and wildernesses, GNP seems to be in a

relatively fortunate position in terms of its fire management. The west-side forests are still experiencing largely natural succession due, in part, to the fact that large fires have replaced stands on many thousands of acres within the past 80 years. Moreover, stands west of the Continental Divide typically experience fire intervals that range from 150 to 300 years or more, and 70 years of suppression would not substantially lengthen a stand's fire interval unless it had already been very long when suppression occurred. Even where fire suppression might have actually lengthened a stand's fire interval, such as along Snyder Ridge, there generally has not been enough time for unnatural succession to be noticeable. However, long-term fire suppression eventually would alter the character of the forest mosaic. Much of the mosaic would age uniformly, possibly encouraging more-extensive mountain pine beetle epidemics in lodgepole pine forests. Consequently, future fires might be even larger than were characteristic before 1910.

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APPENDIX

McDonald Basin Master Fire Chronology

(age class [fire] locations appear in figs. 2,3)

A. Fires documented in fire atlas (*= major fire year):

***1967**--Flathead Fire (Apgars) (8855 ac.)
***1967**--Glacier Wall Fire (3109 ac.)
***1936**--Heaven's Peak Fire (7500 ac.)
***1929**--Half Moon Fire (6696 ac. in study area, 30,000+ ac. surrounding area)
***1926**--Apgar Fire (4799 ac.)
1925--Apgars (1600 ac).
1925--Apgars (2248 ac).
1919--Huckleberry Fire (54 ac).
1919--Trout Lk. (1279 ac).
1914--Howe Lk. (161 ac).

B. Estimated fire years documented by age class sampling (n= number of sample trees):

1913--mid-Avalanche Cr. (est. 600 ac.)(n=3)
1899--small class near lower Mt. Brown Lookout trail (est. 100 ac) (n=3)
***1889**--(northwest of main study area in lower Camas/Howe Cr.) numerous mosaics less than 600 ac. each (n=6).
1880--northern Howe Ridge (less than 100 ac.)(n=11).
***1866**--(northwest of main study area in mid Camas Cr.) numerous mosaics less than 600 ac. each (n=10).
1861--lower Avalanche Cr. (est. 1000 ac)(n=4).
1856--near GNP HQ in W. Glacier (est. 400 ac) (n=4).
1838--small class s. of McGee Mdw. (est. 300 ac) (n=2).
1813--southeast side of mid Lk. McD (lower Snyder Ridge)(est. 700 ac.) (n=3)
***1798**--Fern and Fish Cr area (est. 3000 ac) (n=13).
1779--southwestern Apgars, remnant class near old Flathead R. Sta.(n=3).
1773--small class in Fish Cr. Campgrd (n=3).
1769--sm. to mod. class near John's Lk. to Avalanche Cr. (n=13).
1761--sm. class near Camas/Fish Road Intersection (n=3).
***1735**--major class found throughout mid- to upper study area; most extensive old growth class; the fire(s) burned est. 20,000+ acres in total (n=46).
***1671**--mod. class along southern Howe Ridge and remnants near Apgar (n=10).
***1628**--mod. class along the northern portion of Howe Ridge, extending northwest into the Rodgers Lk. area, and to top of Camas Ridge (n=8).
1517--earliest age class evidence; remnant of sm. to mod class in the Avalanche drainage and near lower Haystack Cr. (n=5).

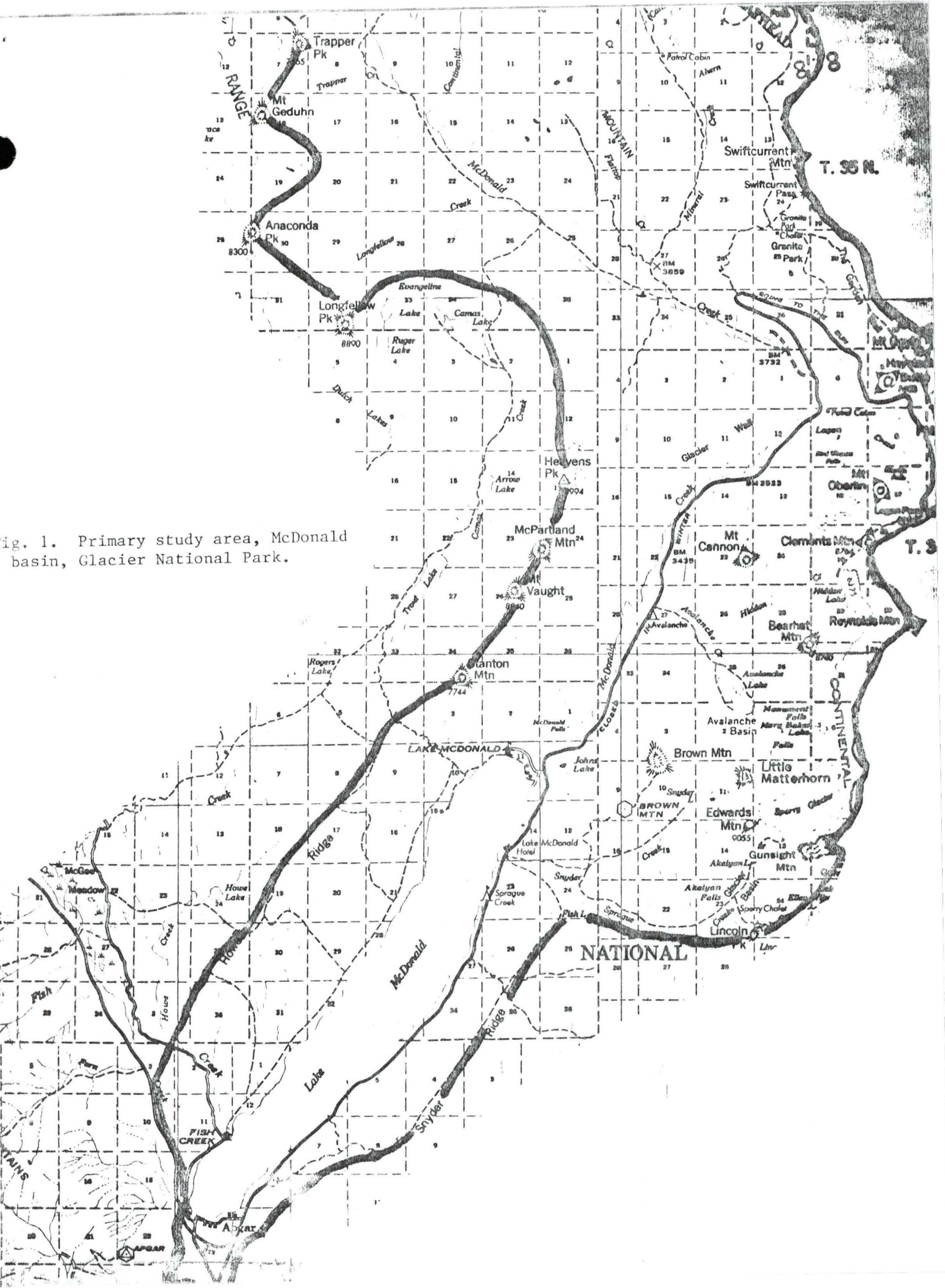


Fig. 1. Primary study area, McDonald basin, Glacier National Park.

Fig. 2. Age classes in south and central portions of study area(for clarity, remnant stands smaller than 200 ac. not shown). There is roughly equal coverage of less than 60 yr. and greater than 250 yr. old stands.

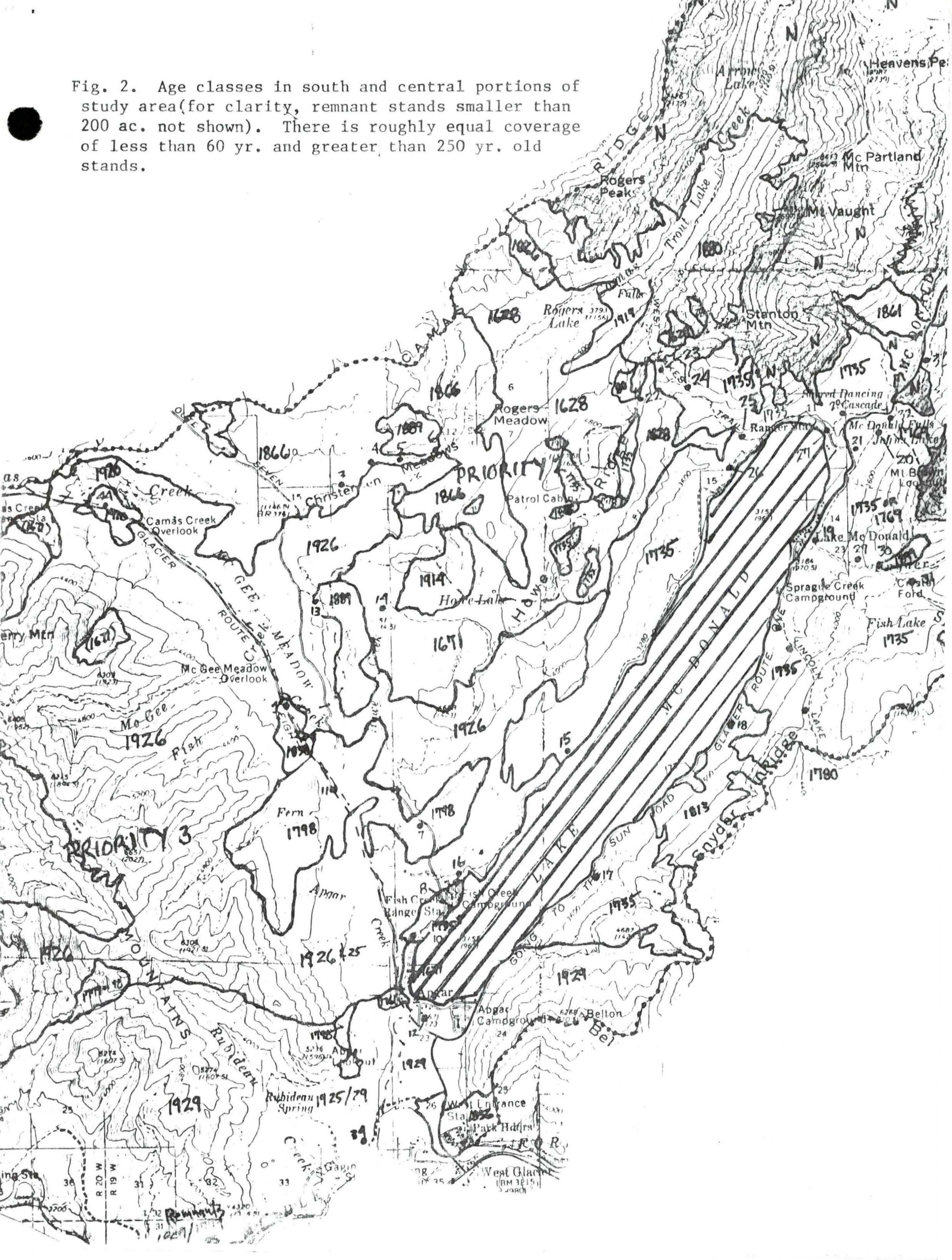

Fig. 2 (cont.). Age classes in northern part of study area. The majority of classes ("N") are "non-fire" environments: uneven-aged spruce-fir, avalanche and alpine communities, cliffs. The 1967 Glacier Wall and 1936 Heaven's Peak fires appear in right-center of map (1936 fire crossed Cont. Divide through Swiftcurrent Pass).

Fig. 3. Uniformly young age classes in Apgar Mts. The 1929 class covers an additional 20,000+ acres south and southeast of the GNP boundary.

Fig. 4. Early and late successional stages after stand-replacing fire in the Subalpine fir/Clintonia habitat type ("R"=post-fire seral regeneration).

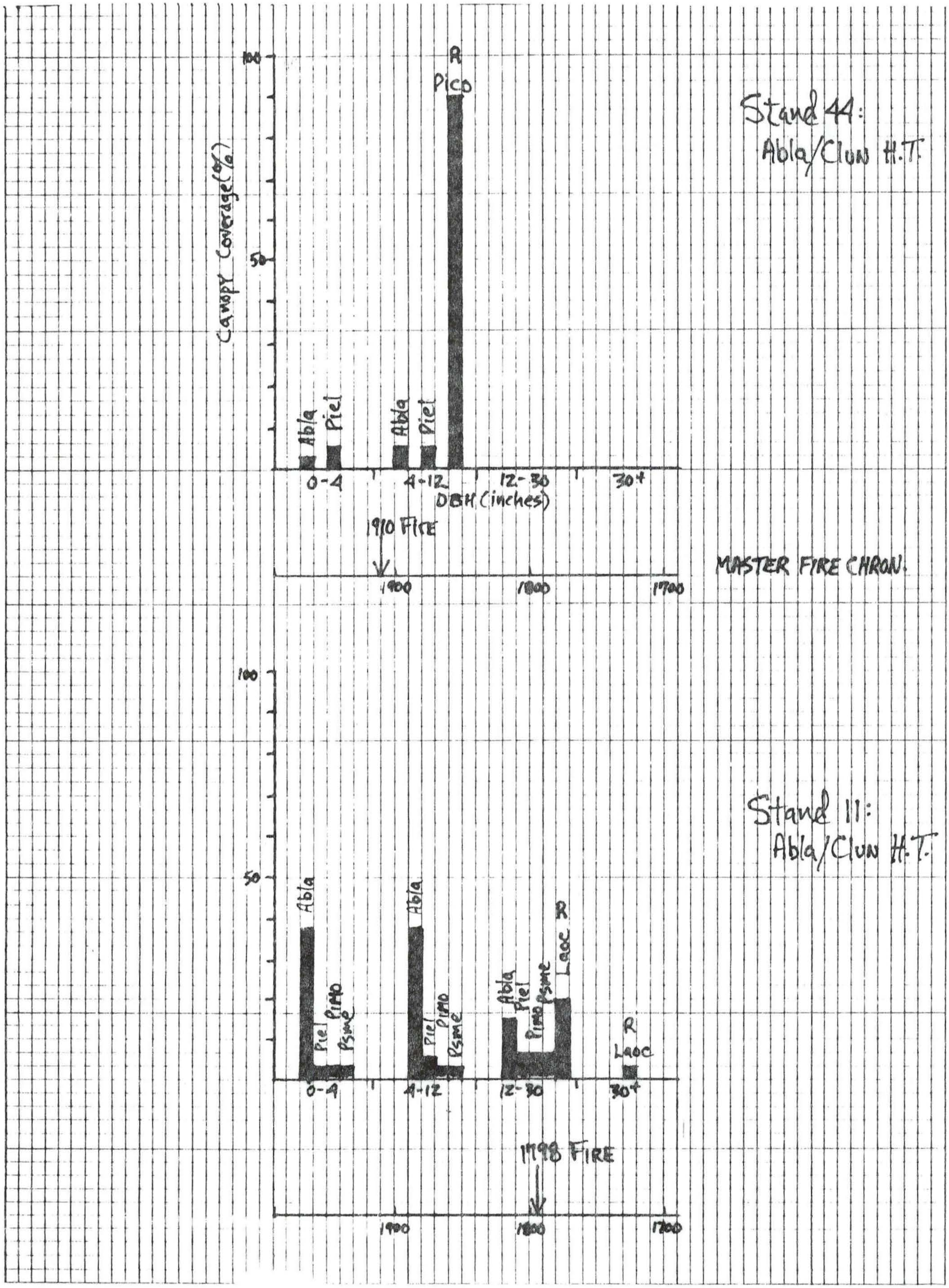

Fig. 5. Early and late successional stages after stand-replacing fire in the cedar and hemlock/Clintonia habitat type ("R"=post-fire seral regeneration).

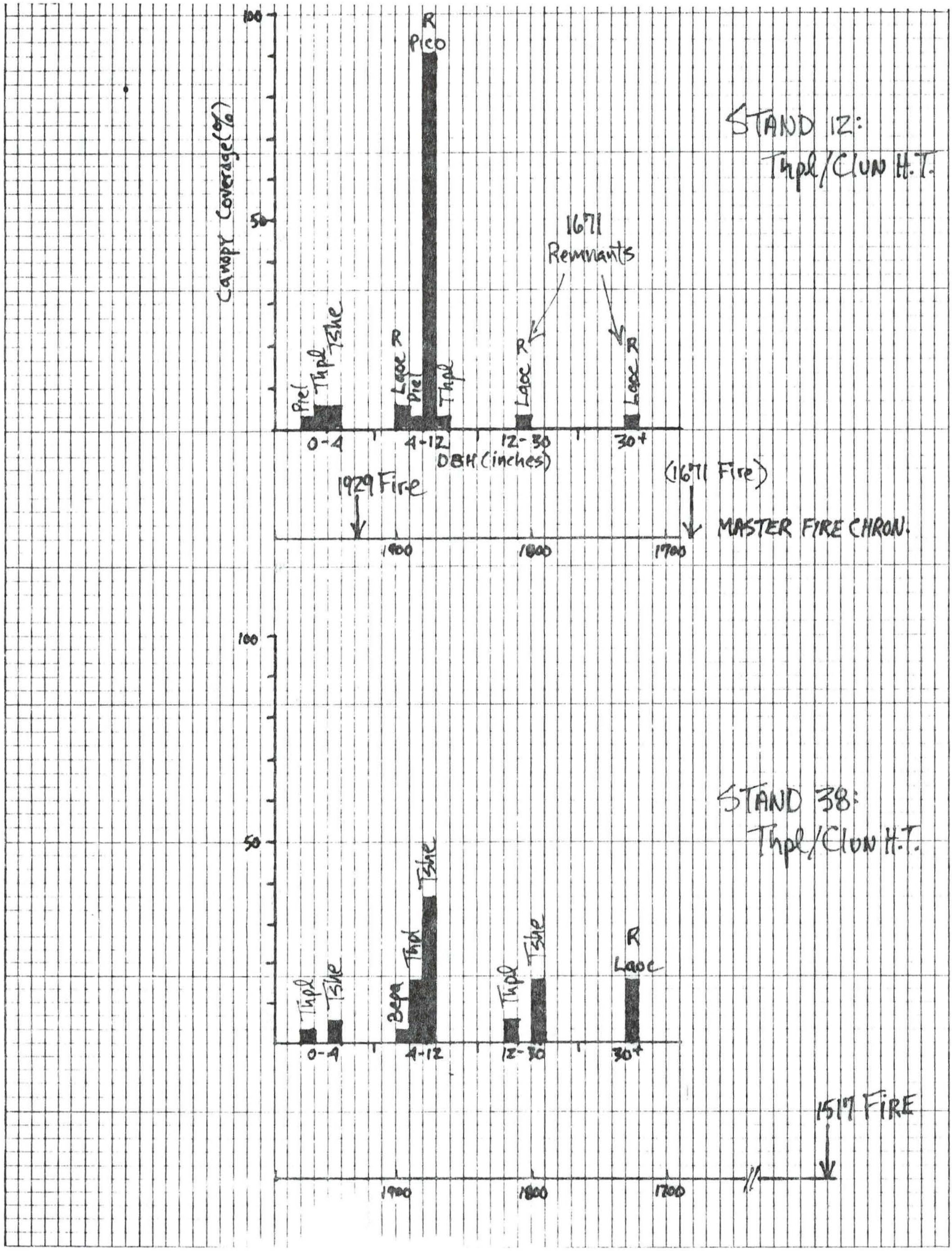

Table 1. Age class chronologies and estimated fire frequencies for 11 stands in the lower elevation forests of the McDonald Creek basin, Glacier National Park.

| Stand No.[1] | Habitat Type[2] | Age Class Origin Yrs.[3] | Complete Fire Intervals (yrs) |
|---|---|---|---|
| 8 | Abla/Clun/Xete | 1735-1926 | 191 |
| 12 | Thpl/Clun/Clun | 1671-1926 | 255 |
| 23 | Abla/Clun/Xete | 1628-1880 | 252 |
| 25 | Thpl/Clun/Clun | 1735-1880 | 145 |
| 30 | Thpl/Clun/Clun | 1735-1899 | 164 |
| 34 | Abla/Libo/Xete | 1798-1929 | 131 |
| 35 | Picea/Clun/Vaca | 1779-1929 | 150 |
| 39 | Thpl/Clun/Clun | 1517-1861 | 344 |
| 40 | Thpl/Clun/Clun | 1707-1913 | 206 |
| 42 | Thpl/Clun/Clun | 1517-1967 | 450 |
| 43 | Abla/Xete/Vagl | 1735-1936 | 201 |

Fire Frequencies (yrs)

Interval Range : 131-450
Median Interval : 201
MAFI : 226

1/ Stand locations appear in figs. 2 and 3.
2/ Habitat type acronyms follow Pfister et al.(1977).
3/ Estimated or known years of successive stand-replacing fires on the site (pre-1910 years estim... from stand initiation years).

United States Department of Agriculture

Forest Service

INT - IFSL

C

Reply to: 4040

Date: March 4, 1988

SES

Subject: Cooperative Agreement INT-87232

SES

To: 2. Director, INT

THRU: 1. ~~Richard C. Krebill, ASD-R~~ QBK

3. ~~BFRA~~

~~IN TURN~~

4. Library

Enclosed is the final report for the Cooperative Agreement (INT-87232) with S.E.M. dealing with Fire History and Patterns of Succession in the McDonald Creek Drainage. All obligations of the Coop have been fulfilled; thus, we would like you to terminate the agreement. Thank you.

James K. Brown

JAMES K. BROWN
Project Leader
RWU 4403

Enclosure

entered on DB #278